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GROWING HORTICULTURAL PLANTS. HORTICULTURE-SERVICE OCCUPATIONS, MODULE NO. 4.

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ONE OF A SERIES DESIGNED TO PREPARE HIGH SCHOOL STUDENTS FOR HORTICULTURE SERVICE OCCUPATIONS, THIS GUIDE HAS AS ITS MAJOR OBJECTIVE TO DEVELOP THE UNDERSTANDINGS AND ABILITIES REQUIRED TO GROW HIGH-QUALITY HORTICULTURAL PLANTS. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF DATA FROM STATE STUDIES. SUBJECT MATTER AREAS ARE (1) ECONOMIC AND AESTHETIC VALUES OF FLOWER, FRUIT, AND VEGETABLE PLANTS, (2) PLANT GROWTH, (3) PLANT PARTS, (4) PLANT LIFE PROCESSES, (5) PLANT ENVIRONMENT CONTROL, (6) TRANSPLANTING, AND (7) CULTURAL PRACTICES. SUGGESTIONS ARE INCLUDED FOR INTRODUCTION OF THE MODULE, SPECIFIC UNIT OBJECTIVES, SUBJECT MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS AND REFERENCES, AND EVALUATIVE PROCEDURES. THIS MODULE IS SCHEDULED FOR 40 HOURS OF CLASS INSTRUCTION, 57 HOURS OF LABORATORY AND 70 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS WITH A BACKGROUND IN HORTICULTURE MAY USE IT TO PLAN A UNIT FOR LESS ABLE HIGH SCHOOL STUDENTS WHO HAVE AN OCCUPATIONAL GOAL IN ORNAMENTAL HORTICULTURE. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 619 - 000 631) FOR $7.25 FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

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GROWING HORTICULTURAL PLANTS

One of Twelve Modules in the Course Preparing for Entry in
HORTICULTURE - SERVICE OCCUPATIONS

Module No. 4

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

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M E M O R A N D U M

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Describe Suggested references given in module. (P)

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GROWING HORTICULTURAL PLANTS

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GROWING HORTICULTURAL PLANTS

Major Teaching Objective

To develop the necessary understandings and abilities required to grow high-quality horticultural plants

Suggested Time Allotments

At school		
Class instruction	40	hours
Laboratory experience	57	hours
Total at school	97	hours
Occupational experience	70	hours
Total for module	167	hours

Suggestions for Introducing the Module

1. Prepare a display of many colorful seed packets and seed specimens and quality flowering plants represented by the seed packets and specimens. Relate the plants to the seeds by asking such questions as: How could this beautiful, large plant develop from this rather unattractive, small seed?

   How does one grow high-quality plants from seeds?

   Can plants be expected to grow from seeds carelessly thrown into the ground?

   How can one account for some people's growing fine healthy plants while others have very little success in growing plants?

2. Display a rooted taxus, a juniper, or a rhododendron cutting and compare it to a balled and burlapped two or three-year-old plant of the same type. Use a line of questioning as in Item 1 above.

3. Display two tomato plants (or other suitable plants), one of which is obviously of poor quality, and the other of good quality. Ask the students what difference the knowledge of growing plants makes.

4. Make a list of items that one should know if he is to grow plants successfully and profitably. This list might include the following:

   a. Plant parts

   b. Plant life processes

   c. Plant environment

   d. Growing containers

   e. Cultural practices

   f. Varieties

   During the next several days, plant-growing will be the subject of the course.

Competencies to be Developed

I. To appreciate the economic and aesthetic values of flower, fruit, and vegetable plants

Teacher-Preparation

Subject Matter Content

Horticulture, since it includes all of the fruits, vegetables, and nuts produced, provides about forty percent of all food for human consumption. Specific examples of foods from horticulture include:

1. Orange juice
2. Strawberry preserves
3. French fried potatoes
4. Onion rings
5. Peanuts
6. Potato chips
7. Pickles

All food, which is necessary to live, can be traced directly or indirectly to green plants. Because flower, fruit, and vegetable plants are a part of this group, they are, therefore,

extremely inportant in the production of nutritious foods. They are also essential to good health because they supply necessary bulk and calories to the diet.

They also beautify homes and landscapes with grass, flowers, trees, and shrubs.

They also provide countless thousands of jobs that involve not only growing plants, but also harvesting and processing plants or plant parts and marketing and distributing the products. For instance, a crop of tomatoes could provide the following jobs:

1. Someone must produce the tomato seed to grow the plants for the crop. Tomato seed producers must employ such workers as the following:

   a. Soil cultivators

   b. Plant setters

   c. Geneticists

   d. Plant pathologists

   e. Record clerks

   f. Sprayers

   g. Harvestors

   h. Seed processors

   i. Seed salesmen

2. Someone must manufacture the equipment to prepare the soil, plant the crop, harvest the crop, process the crop, distribute the products, and keep the crop records. This work involves such workers as:

   a. Ore extractors

   b. Ore refiners

   c. Steel mill employees

   d. Factory workers

   e. Machinery setup men

f. Parts clerks

g. Agricultural engineers

h. Salesmen

i. Managers

3. Someone must grow and harvest the crop, providing jobs for:

a. Soil tillers

b. Plant setters

c. Crop cultivators

d. Irrigators

e. Crop sprayers

f. Crop harvestors

g. Truck loaders

h. Truck drivers

i. Mechanics

j. Credit managers

k. Bankers

4. Someone must market the crop, providing jobs for:

a. Buyers

b. Sellers

c. Secretaries

d. Truck drivers

e. Receiving clerks

f. Weighers

g. Managers

5. Someone must process the crop, involving such workers as:

   a. Canning factory employees

   b. Can and carton designers

   c. Packers

   d. Loaders

   e. Unloaders

   f. Truck drivers

   g. Managers

6. Someone must market the finished produce, providing jobs for many other workers.

   Similar examples could be given for other horticultural and agricultural crops. Do you understand now how horticulture creates many jobs?

Plants are also valuable because they are sources of:

1. Fuel (wood, peat, coal, oil, natural gas)

2. Building materials (lumber, turpentine, rubber, linseed oil, bamboo, and other such materials)

3. Medicines (quinine, codeine, morphine, and others)

4. Clothing and textiles (cotton silk, flax, wool)

5. Insecticides (pyrethrum)

6. Recreation (national, state, and local parks)

Plants can also improve soil structure and fertility and prevent soil erosion.

Because plants are commonplace to us, their real significance may be overlooked. Insofar as green plants are indispensable to life and the economy, it is absolutely essential that good plants be grown. If a person has a basic understanding of and appreciation for plants, he should be able to grow good plants. For this reason, this competency has been included in this module. The teacher should devote sufficient time to developing in the students a wholesome attitude toward plants and plant study.

Suggested Teaching-Learning Activities

1. Introduce the competency by posing this situation to the class:

   Assume that somehow all plant life had disappeared from the earth. How would this affect you and the way you live? Name several ways plants, and especially horticultural plants, affect you and your way of life. (The response may be either written or oral.) Compile a list of the responses on the chalkboard. Elaborate on the responses to create in the students an interest in plants. Use the approach that plants are so valuable and important that they must be grown well.

2. Show the film "Miracles from Agriculture," which tells how high-quality foods result from efficient production and marketing and shows new uses of farm products for consumers and industry. It reports on today's farming and ranching, marketing, processing, storing, transporting, and merchandising of food and other agricultural products.

3. Compare a plant to a living animal, such as a pet dog. Emphasize that plants need regular care and attention just as do pets.

4. Encourage interest and enthusiasm for plant study by displaying unusual and interesting plants such as the sensitive plant or the Venus fly trap and allow the students to work with them.

5. Suggested time to develop this competency:

Classroom instruction	2	hours
Laboratory activity	1	hours
Total time	3	hours

Suggested Instructional Materials and References

Instructional materials

1. Film, "Miracles from Agriculture"
2. Curious plants of various types

Reference

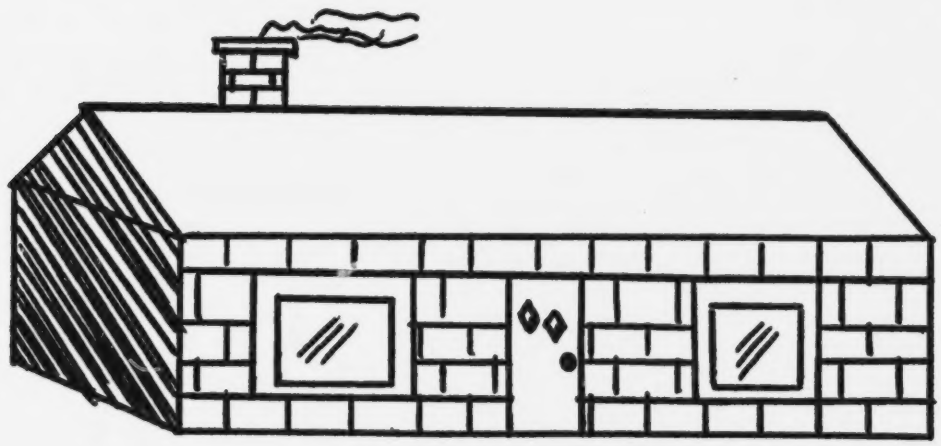
Introductory Horticulture, pp. 2-3.

II. To understand how plants grow

Teacher-Preparation

Subject Matter Content

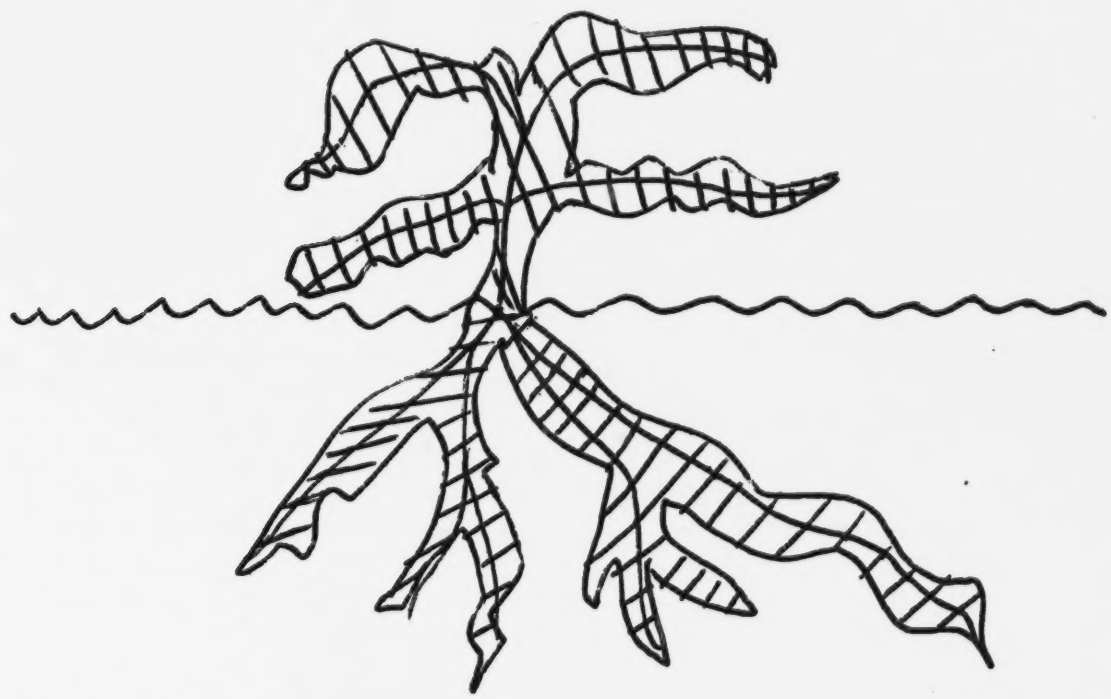
Figure 1
Brick House



A house can be made of many small units (bricks).

In order to make the house larger, it is necessary to add more bricks.

Figure 2
Plant



This plant, like a house, is made up of many small units (cells).

In order for the plant to grow larger, it must add more cells. These two sketches will be helpful in making these points:

1. In the house, several bricks are used together to form a wall; others are used to form a chimney; still others form a patio or planter. In the plant, cells are grouped together to form water-conducting tissue, food-conducting tissue, leaves, roots, stems, flowers, fruits, and seeds.

2. Bricks can be easily identified because they have these characteristics:

   a. All are large enough to be seen with the unaided eye.

   b. All have the same general shape.

   c. All are made from the same material.

   d. All are about the same size.

   e. All contribute to the make-up of the house.

   Plant cells, however, cannot be easily identified. Their characteristics, which are less specific, include:

   a. Most plant cells are too small to be seen with the unaided eye and can be observed only with a microscope.

   b. Not all cells have the same shape. Some are shaped like soda straws, while others are shaped like stop-signs or other objects.

   c. Some cells are larger than others.

   d. Some parts are found (cell wall, nucleus, protoplasm, vacuoles) in all plant cells, whereas other parts (the plastids) are found only in certain cells.

   e. All cells contribute to the makeup of the plant.

3. As bricks are the basic units of the brick house, so cells are the basic units of the plant. No house can be better than the bricks of which it is built, and no plant can be better than the cells of which it is composed. In order to have good plants, it is necessary to develop good cells.

4. To enlarge a brick house, one can obtain more bricks from the brick factory, but a plant must produce its own cells, by cell division, to grow. In order for cell division to occur, energy and protoplasmic materials (which are obtained from food) must be available. Once the cells have divided, the plant increases in size or grows.

5. Plants grow in length, in diameter, and in substance. Increase in length occurs mostly at the tip regions of roots and stems. Increase in diameter of plants occurs only in those plants having a layer of actively-dividing cells which is just inside the rind or bark.

   (For additional material on plant cells and tissues, see Horticultural Science, pp. 52-62.)

   The direction in which plant growth occurs is affected by such factors as light, water, gravity, heat, chemicals, and pressure. Some parts of the plant may grow in the direction of the factor (stimulus), whereas other parts of the same plant may grow away from the factor (stimulus). For example, plant roots tend to grow toward the pull of gravity, whereas plant stems tend to grow away from this pull of gravity.

   At this point, conduct demonstrations to illustrate the responses of plants to various stimuli, as found in chapter ten of Teaching High School Science: A Sourcebook for the Biological Sciences.

The following are significant points concerning plant growth:

1. Plant growth can be separated into two phases:

   a. Vegetative growth: the growth and development of roots, stems, and leaves

   b. Reproductive growth: the initiation of flower buds and the development and formation of flowers, fruits and seeds

2. Plant growth does not proceed steadily at a regular rate but is subject to daily and seasonal variations in rate.

3. Plant growth can be thought of as the cell division, enlargement, and specialization (differentiation) processes whereby new plant organs and tissues develop.

4. Plant dormancy tends to result from environmental factors and chemicals known as hormones.

5. Some plants, such as evergreens, may have several periods of active growth, or flushes, during the season.

At this point, perform some demonstrations to measure the growing regions of a plant. Such demonstrations may be found in Teaching High School Science: A Sourcebook for the Biological Sciences, pp. 109-110.

Suggested Teaching-Learning Activities

1. Using a picture of a brick house and an actual plant as the focal points of interest, point out the unit construction of both a brick house and a plant.

2. Place a leaf section of Tradescantia or other suitable plant under a microscope to allow students to view the cellular composition of a leaf. Discuss the nature of cells.

3. Conduct class demonstrations on response of plants to various stimuli and on plant-growing regions, as suggested in the subject matter content.

4. Exhibit a cell model and discuss the basic parts: cell wall, center of cellular control (nucleus), and living material (protoplasm).

5. Suggested time to develop this competency:

Classroom instruction	2	hours
Laboratory activity	2	hours
Total time	4	hours

Suggested Instructional Materials and References

Instructional materials

1. Microscope (Borrow from biology department, if possible.)

2. Picture of a brick house

3. Potted plant

4. Model of a cell (Borrow from biology department).

References

1. Horticultural Science, pp. 52-62.

2. Teaching High School Science: A Sourcebook for Biological Sciences, pp. 109-110 and Chapter 10.

III. To understand the role of the various plant parts in plant growth

Teacher Preparation

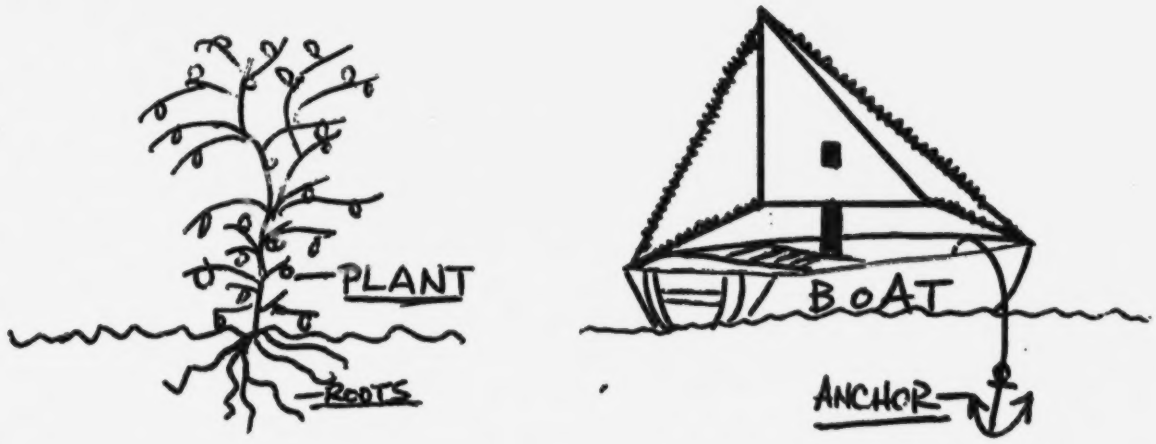
Subject Matter Content

A suggested introduction to the role of roots in plant growth:

Can you imagine

A house with no foundation?
A truck with no wheels?
A train with no tracks?
A boat with no water?
A skater with no skates?
A plant with no roots?

Figure 3



Roots perform three functions:

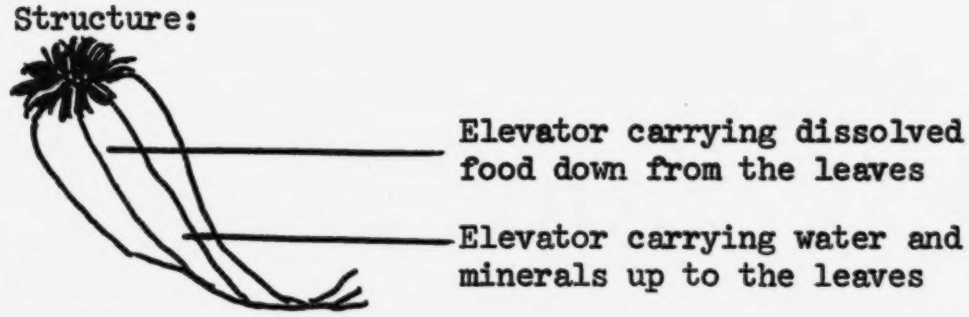
1. They serve to anchor the plant.
2. The take water and minerals from the soil into the plant.
3. They store food.

The two basic types of root systems are:

1. Taproot (Examples: carrot, beet, and parsnip)
2. Fibrous (Examples: grass, corn, cactus)

Figure 4

Root Structure:



The root is very important to the plant because it anchors the plant and absorbs water and minerals from the soil. Once in the root, the water and minerals move up through a root elevator system into the stem and leaves.

The following class demonstration may be helpful to show how water is absorbed by roots:

1. Materials required
   a. Large, fresh carrot
   b. Cork borer
   c. One 3-foot length of glass tubing
   d. Concentrated sugar solution
   e. One-hole rubber stopper, No. 5 size
   f. Red food coloring
   g. Ring stand
   H. Burette clamp
   i. Quart jar of water
2. Procedure

   Using the cork borer, hollow out a two or three-inch-deep cylindrical cavity in the top center of the carrot. Add the red food coloring to the sugar solution and carefully pour the mixture into the carrot cavity. Insert the glass tubing into the one-hole rubber stopper so that it will extend well

into the solution when the stopper is fitted into the cavity. Immerse the carrot with the fitted tube in the quart jar of water and support the carrot and tube with the ring stand and burette clamp. Mark the level of the colored fluid in the tube at different time intervals. The colored water will move upward in the tube and may be observed and measured from the reference lines.

The following factors are required for good root growth:

1. The soil structure and texture should provide good aeration.

2. The soil should have a satisfactory moisture-holding capacity.

3. The soil should contain a good supply of nutrients.

4. The soil reaction should be in a satisfactory pH range (5.8-6.5)

5. The soil temperature should be favorable.

6. The light intensity on the foliage should be of sufficient intensity for plant growth.

Practices which can be used to promote root growth are as follows:

1. Use a mulch to conserve soil moisture during hot, dry weather.

2. Reduce weed competition for soil minerals, water, and light.

3. Use complete fertilizers if soil tests indicate nutrient deficiencies.

4. Lime or acidify, if necessary, the soil to maintain a favorable pH range.

5. Water the soil when it begins to dry out excessively.

6. Walk and operate heavy equipment over the soil only when absolutely necessary.

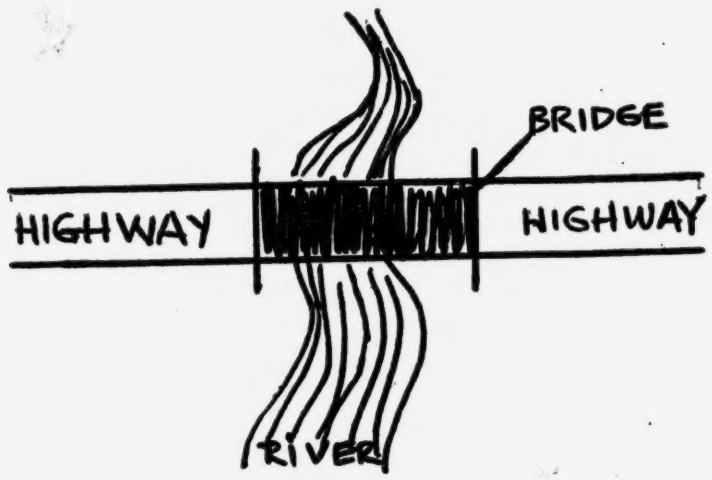
7. Incorporate organic matter into the soil.

8. Drain the soil, if necessary.

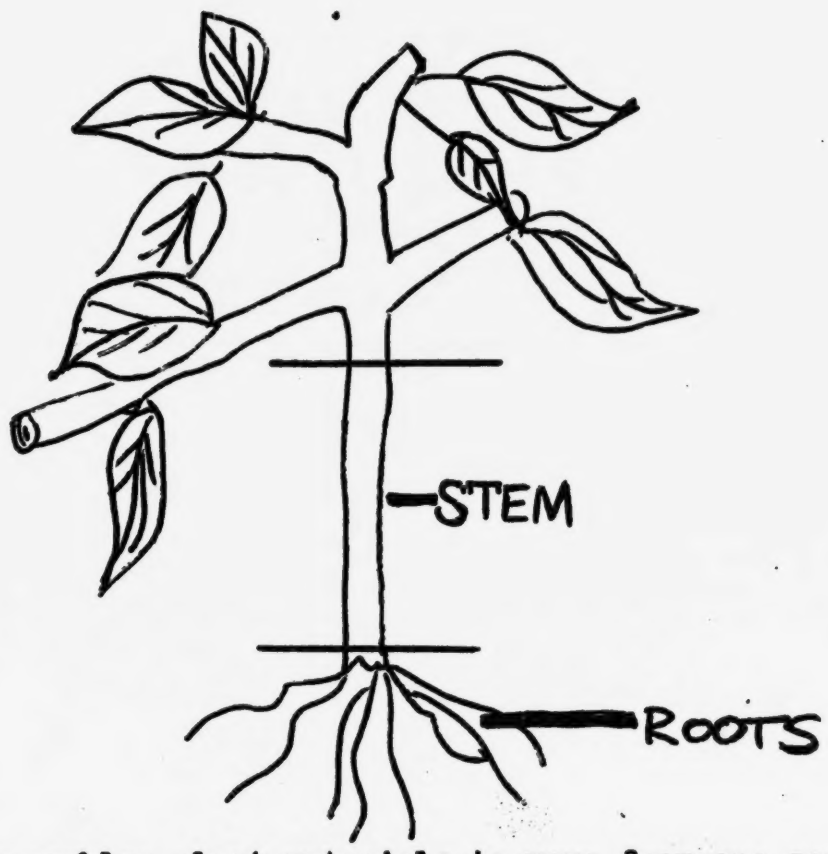
9. Incorporate inorganic materials, such as coarse sand, calcinated clays, and coarse perlite into the soil.

Stems:

Figure 5



The bridge enables traffic to move from one segment of the highway to the other segment.



The stem enables plant materials to move from one segment of the plant to the other segment. In this respect, the stem acts as a bridge.

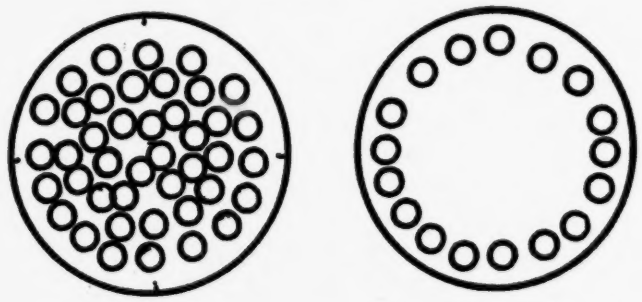
Stems serve the following purposes:

1. They support the leaves.
2. They carry water and minerals from the roots upward to the leaves.
3. They carry dissolved food from the leaves downward to the roots.
4. They store food.

Two basic types of stems exist:

1. One type has its elevators, which contain food-conducting vessels and water-conducting vessels scattered throughout the stem.
2. The other type has its elevators arranged in a ring around the stem.

Figure 7



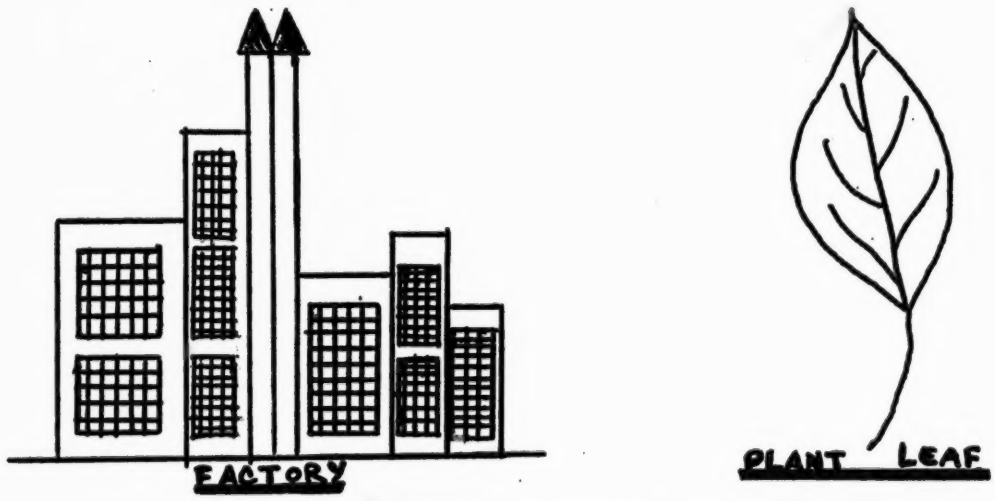
Monocot stem Dicot stem

Practical application of a knowledge of stems permits the following:

1. Determining growth rate and age
2. Making judgment of plant quality on the basis of the internodal strength
3. Killing woody plants by girdling the stem
4. Employing various plant-propagating techniques involving the stem

Leaves:

Figure 8



The leaf of a plant can be compared to a factory, since both leaves and factories manufacture products. The main product of the leaf is food, which plants use for living and growing.

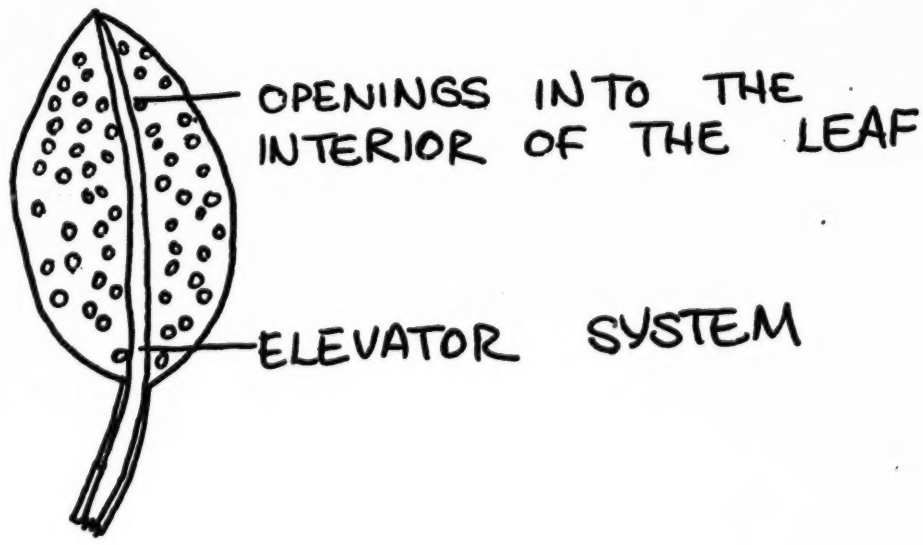
Activities of the leaves:

1. Leaves are the chief center of food manufacture in the plant.

2. Leaves take in and give off the invisible gases of carbon dioxide, oxygen and water. These materials are extremely important to both plant and animal growth.

Leaf Structure:

Figure 9



The important structures in the leaves are the elevator system, the hundreds of small openings into the interior of the leaf, and the green cells making up the leaf.

The small openings allow materials needed for food manufacture to enter the plant and allow by-products and water to leave the plant. Through these structures, most of the water is lost from the plants.

At this point, make some demonstrations of transpiration. Several are to be found in Teaching High School Science: A Sourcebook for the Biological Sciences, pp. 46 - 50.

Suggested Teaching-Learning Activities

1. Display and label several plants having tap roots and several with fibrous roots. The roots should be washed free of soil so that their forms can be easily perceived by students.

2. Discuss the activities, basic structure, and environmental requirements of roots.

3. Take a green bean or similar plant and cut the stem in two pieces. Ask the class what will happen to a plant when the stem is lost. This approach should provide interest in the activities and functions of stems in plant growth. Discuss the types of stems, pointing out the following:

   a. Because of the presence of a layer of actively-dividing cells (cambium), only dicot stems have the capacity to increase in diameter after all other cells have enlarged fully.

   b. Grafting is useful with dicot plants.

   c. Review practical applications of a knowledge of stems. (See subject matter content for these applications.)

4. Mount cross sections of monocot and dicot stems on microscopic slides and allow the students to examine them. Young corn and sunflower stems are good for this purpose. (These may be prepared ahead of time.)

5. Compare leaves to factories while discussing the activities and characteristics of leaves.

6. Allow the students to see the openings (stomata) in leaves, using the Tradescantia zebrina as the specimen leaf.

7. Suggested time to develop this competency:

Classroom instruction	4	hours
Laboratory activity	2	hours
Total	6	hours

Suggested Instructional Materials and References

Instructional materials

1. Carrot, beet, grass, corn, and bean plants to serve as examples of root systems
2. Compound microscope(s)
3. Tradescantia zebrina for leaf examination
4. Cross-sections of young corn and sunflower plants
5. Beaker or quart jar, 800 ml in size
6. Ringstand
7. Burette clamp
8. Three-foot glass tube
9. One No. 5 one-hole rubber stopper
10. Syrup
11. Red food coloring
12. Cork borer
13. Root, leaf, and stem models, if available (Borrow from biology department.)

References

1. Modern Biology, Chapters 10-14.
2. Teaching High School Science: A Sourcebook for the Biological Sciences, pp. 46-50.

IV. To understand how plants live

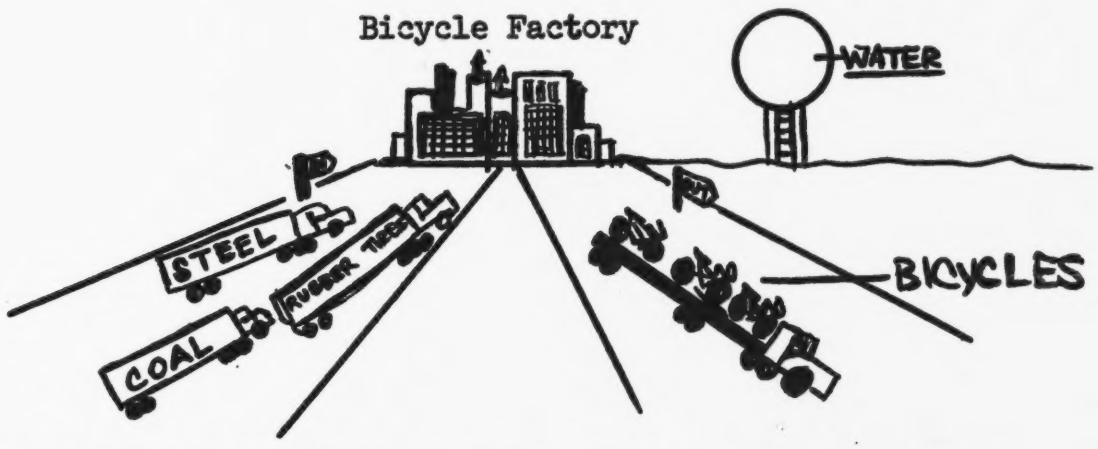
Teacher Preparation

Subject Matter Content

To introduce this competency, relate the following story:

Last night, my cousin, who works in a bicycle factory, came to my house. During the course of our conversation, we talked about what is necessary to operate a bicycle factory.

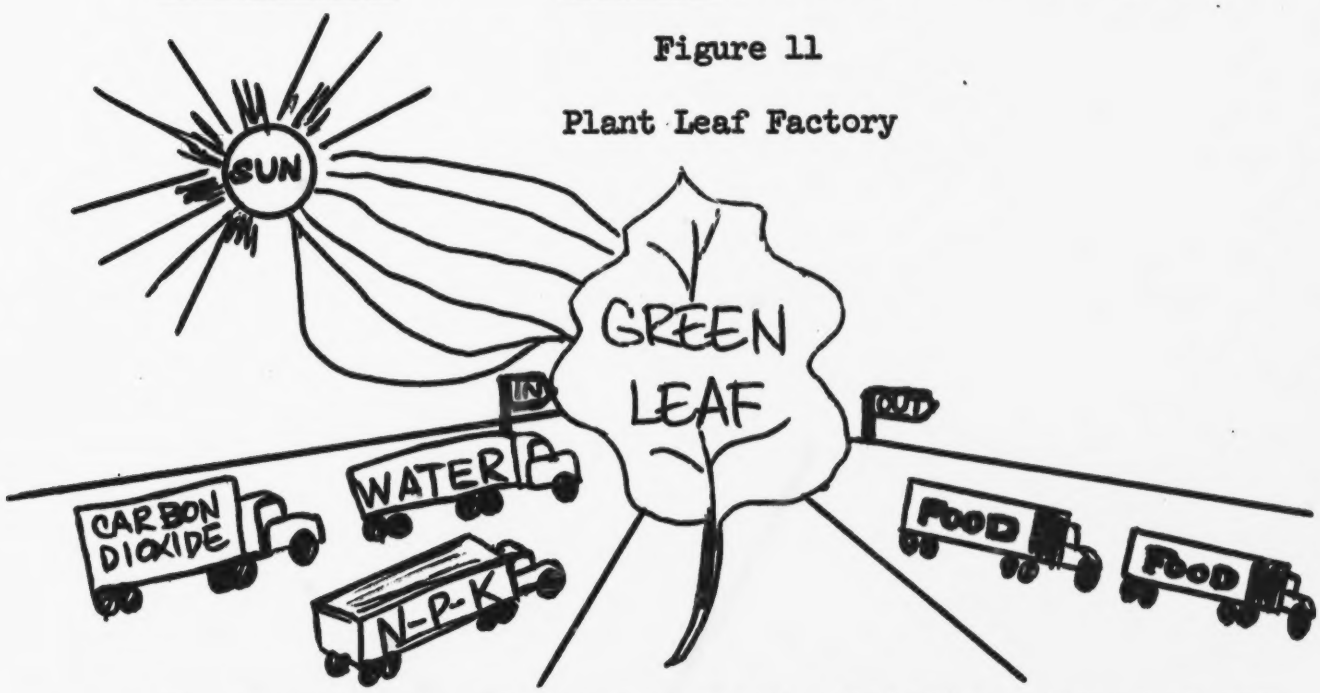
Figure 10



A factory uses such things as coal, steel, water, and other raw materials to make finished products, such as bicycles.

Figure 11

Plant Leaf Factory



The green leaves of plants are like factories. They use raw materials, such as carbon dioxide, fertilizer, and water, to make the finished product, food.

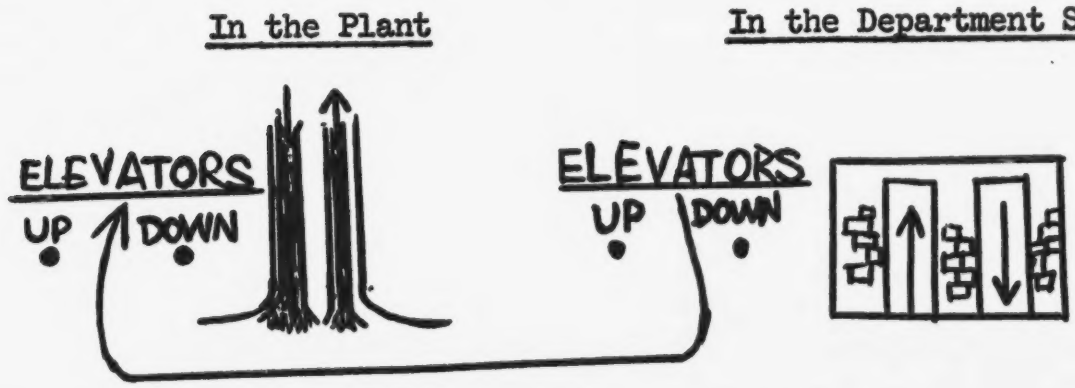
These points can be made from the two sketches:

1. The materials and conditions required for food manufacture in green plants

2. The principle of limiting factors

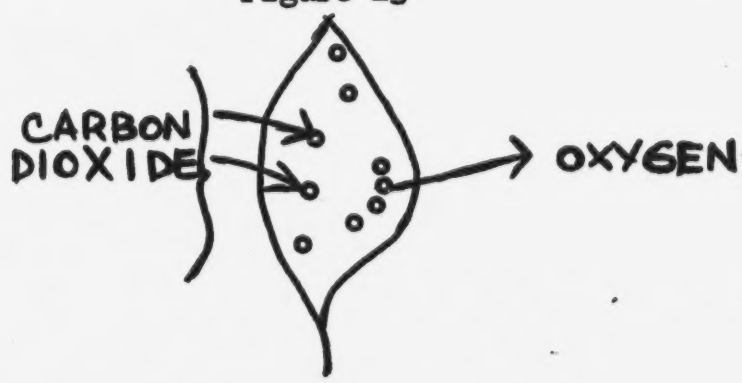
3. The structures involved in moving materials into and throughout plants. Example: We know that carbon dioxide, water, and fertilizer are not brought to green plants in trucks, but that these materials must move into and throughout plants. How does this movement occur?

Figure 12



In the green plant, food dissolved in water moves from the leaves down to the roots. Water and fertilizers move from the roots up to the leaf factory. The parts of the plant in which food, water, and fertilizers move are like elevators.

Figure 13



Daytime

Carbon dioxide enters the plant through hundreds of little openings in the leaves, called stomata, and oxygen leaves the plant through the same openings.

The following questions may be used in conjunction with the sketches:

1. What would happen to bicycle production if the steel truck had a flat tire? the rubber tire truck? the coal truck?

2. What would happen to food production in green plants if the carbon dioxide "truck" had a flat tire? the water truck? How could these trucks get flat tires?

3. What happens to the bicycles made at the bicycle factory?

4. What happens to the food made by the green plant?

5. What happens if the bicycle factory cannot make bicycles?

6. What happens if the plant cannot make food? When might this happen?

7. What happens if the bridge in the road leading to the factory is washed out?

8. What happens in the plant if the elevator system breaks down? How could this happen in the plant?

9. What happens in the plant if the little openings admitting carbon dioxide get plugged up? How could this happen?

10. Since plants are not supplied with raw materials in trucks, where do they come from then?

11. What happens if the plant leaf is not green?

12. What happens if there is no sunlight, such as at night or on cloudy days?

13. Since roots do not live in sunlight, how do they get their food?

14. Why are many kinds of green plants, not grown successfully under greenhouse benches, in heavily shaded areas of the nursery, or under large trees on the golf course?

15. Why can some plants grow better in the shade than others?

16. What happens to the manufacturing of food in the leaf factory if the temperature is too cold, or if it is too hot?

17. How can this lesson be applied to the job?

    a. Keep leaves clean.

    b. Grow plants under adequate light intensity.

    c. Keep the air moving.

    d. Prevent insects and disease from clogging the elevators of the plant.

    e. Paint the inside of the greenhouse white.

    f. Keep the greenhouse glass clean.

Students will probably appreciate concrete proof of what has been discussed in class. Many demonstrations of photosynthesis can be performed, such as the following:

1. Oxygen release from elodea

2. Starch test on green leaves or red-pigmented leaves

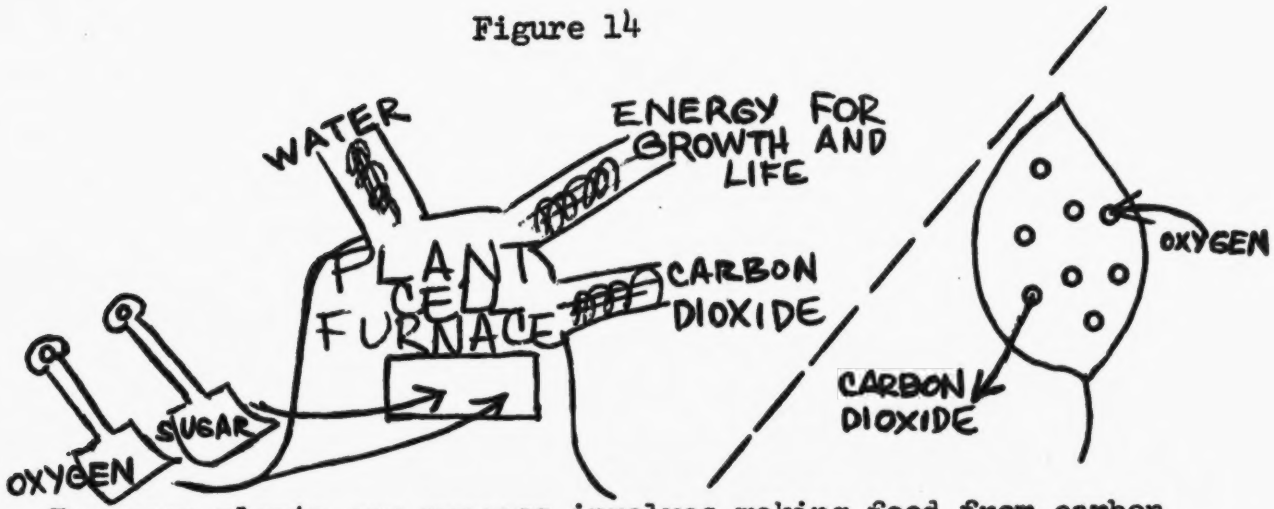
3. Looking at the stomata in leaves under the microscope

4. Growing plants in light and in dark

5. Chlorophyll extraction

Suggestions for conducting these demonstrations can be found in Teaching High School Sciences: A Sourcebook for the Biological Sciences, Chapter 1.

Figure 14



In green plants one process involves making food from carbon dioxide and water when the light is bright enough; whereas another process involves using the food that has been made by the plant to release energy necessary to keep the plant alive and growing. The food-making process occurs only in the green portions of a plant and only when sufficient light and raw materials are present. The food-using process occurs all the time, day or night. In the food-making process, which tends to decrease the weight of the plant, the energy is stored; in the food-using process, energy is released.

The amount of light which green plants receive is very important. During periods of dark, overcast days, a plant may use more food than it makes, since the food-using process goes on all the time regardless of whether the sun is shining or not. This is especially true if a high temperature is maintained in the greenhouse. Thus, the greenhouse operator, should lower the temperature at night during periods of prolonged cloudy weather to slow down the food-using process.

Suggested Teaching-Learning Activities

1. Prepare individual copies of the bicycle and plant leaf factory sketches for class distribution, or prepare two large posters of these sketches as the basis for the class discussion which may be based on the seventeen suggested questions given in the subject matter content.

2. Conduct demonstrations on photosynthesis, as suggested in the subject matter content.

3. Compare the food-making process (photosynthesis) with the food-using process (respiration) in non-technical terms, as indicated in the subject matter content. A shriveled potato or fruit will serve well to illustrate respiration as a food-using process.

4. Discuss the practical application of a knowledge of photosynthesis and respiration.

5. Show the film "Our Mr. Sun."

6. Suggested time to develop this competency:

Classroom instruction	4	hours
Laboratory experience	2	hours
Total time	6	hours

Suggested Instructional Materials and References

Instructional materials

1. Posters or copies of the bicycle and plant cell furnaces

2. A shriveled potato or apple to demonstrate that respiration takes place in harvested products as well as in living plants

3. Film, "Our Mr. Sun"

References

1. Introductory Horticulture, pp. 39-44.

2. Teaching High School Science: A Sourcebook for the Biological Sciences, Chapter 1.

V. To develop the abilities and skills required to control the environmental factors affecting plant growth

Teacher Preparation

Subject Matter Content

Suggested introduction: To paint a car, the following conditions must be met:

1. The surface must be clean and free from dust.

2. The surface must be smooth and free from rust and flakes of metal.

3. The surface of the car and the air should be dry.

4. Paint of the right color must be available.

5. Paint applicator equipment must be available.

To grow a plant, certain conditions must be met:

1. Available light must be of correct intensity, quality, and duration.

2. The soil must be suitable to receive the seed or plant.

   a. The temperature must be suitable.

   b. The moisture content should be at the proper level.

   c. Provision must be made for good soil aeration.

Light is closely related to plant growth.

1. Light retards growth, but is absolutely necessary for plant growth and health, since the food-making process depends upon the proper light conditions.

2. Light serves as a stimulus which affects the direction of growth. Stems tend to grow toward the light; whereas roots tend to grow away from the light.

3. There is a desirable range of light intensity for good plant growth. Some plants require rather low light intensity for best growth (foliage plants); whereas other plants require higher intensities for best growth. When the light is too bright, chlorophyll is destroyed and flowers are faded. When the light is too dim, food-making does not occur.

4. The length of time that light is withheld from plants affects the period of time when the plants will produce flowers.

5. Plants grown under poor light conditions tend to have weak, soft, slender stems, thin leaves, poor color, and yellow, dry lower leaves. Vegetative growth is controlled to a large degree by light.

6. Plants grown in very intense sunlight have short, heavy stems, small light-colored leaves, and bleached flower colors.

The following are techniques for controlling light as an environmental factor in plant growth.

1. High light intensity on growing plants may be reduced by using shading cloth or screening above the plants or by placing shading compound on the greenhouse glass.

2. Low light intensity on plants growing in a greenhouse can be increased to some extent by keeping the glass clean, painting interior structures white, and locating the greenhouse away from trees and other sources of shade.

3. Light intensity can be increased to some extent by using artificial lighting. This is impractical on a commercial scale of production, however.

4. Where plants are grown outside, light use may be increased by spacing, training, and pruning the plants.

5. The length of day (or the dark period) can be regulated by using timer-controlled electric lights and black shading cloth.

Temperature also has an important role in plant growth, since all plants have an optimum temperature rate for best growth.

1. High temperatures tend to speed up plant growth.

2. Low temperatures tend to slow down plant growth.

3. Controlled night-time temperature in the greenhouse is important in raising commercial crops. For example, some plants develop into higher-quality plants at a 50°F. night-time temperature.

   a. Carnations

   b. Snapdragons

   c. Stocks

   Other plants develop into higher-quality plants at a 60°F. night-time temperature.

   a. Chrysanthemum

   b. Rose

   c. Poinsettia

4. Temperature affects the rate of water loss from plants and soil.

5. Soil temperature affects the rate of absorption of water and fertilizers by the root system.

6. Temperature affects flower bud development as well as leaf and flower color.

7. Chilling, winter kill, and root damage due to soil heaving are plant injuries commonly associated with low temperatures.

8. Desiccation (burning up) and protein coagulation are examples of high-temperature injury to plants.

The following procedures may be used to regulate the temperature at which plants grow:

1. The temperature range in greenhouses and propagating structures is adjusted by using thermostatically-controlled heating systems.

2. Excessive temperatures in greenhouses are prevented by using conditioning systems, air or fan ventilation systems, and shade, and by watering down the aisles and areas under the growing benches.

3. Heating cables, which increase soil temperature without increasing the temperature of the air surrounding the plant, are particularly effective and desirable in the propagating house.

4. In outdoor situations, mulches are used to stabilize temperatures and avoid temperature extremes.

Moisture is important in plant growth, since all plants need water.

1. Water serves:

   a. To dissolve fertilizer materials and move nutrient solutions within the root zone

   b. As a raw material of photosynthesis

   c. As a solvent of sugars

   d. As a transporting agent for the movement of soluble materials within the plant

2. A plentiful supply of water is essential to cell division and formation of new tissues.

3. Water prevents plant-wilting.

4. Moisture is necessary if cuttings are to take root and seed is to germinate.

5. Water in the form of vapor affects plant growth. The amount of moisture in the air at a given temperature as compared with the amount of moisture which is necessary to produce saturation at that temperature is known as relative humidity.

   The relative humidity of the air influences:

   a. Frequency of watering

   b. Incidence of disease

   c. Food-making as related to stomatal functioning

The following are procedures for controlling moisture level and relative humidity:

1. Careful watering practices must be employed. Unfortunately, no satisfactory rule can be given for the time of watering, since there are so many factors involved. Watering plants can be learned with experience. Watering depends upon such factors as:

   a. Type of plant--Cacti need not be watered so often as chrysanthemums.

   b. Type of growing container--Soil in clay pots tends to dry out much faster than soil in plastic pots.

   c. Amount of sunlight and temperature--Watering should be more frequent during sunny, bright days than during cloudy, overcast days.

   d. Type of soil--Soils high in organic matter require more frequent watering than soils low in organic matter. Sandy soils require more frequent watering than do less coarse soils.

   e. Stage of plant development--Young plants, because of their small leaf surface area, do not require so much water as older plants of the same variety.

f. Relative humidity--As the moisture content of the air increases, the rate of water loss from the plant and the soil surface decreases, thereby reducing the frequency of watering required for maintaining the proper soil moisture level.

2. Relative humidity is best controlled by regulating heat and ventilation.

Low relative humidity increases plant wilting and the frequency of watering required for best plant growth. Conditions of low humidity are corrected by:

a. Watering the walks and under the growing benches of the growing structure

b. Shading the roof to decrease light intensity

c. Using misting systems

High relative humidity, which may lead to disease problems in the greenhouse, especially those diseases caused by fungi, can be controlled with proper ventilation.

Aeration affects plant growth in various ways.

Aeration as a factor in plant growth must be considered in relation to both the soil environment and the aerial environment.

Plants require carbon dioxide and oxygen for life and growth: carbon dioxide as a raw material in the food-making process (photosynthesis), and oxygen to utilize food for energy and growth (respiration). Good ventilation enhances a proper carbon dioxide-oxygen balance in the aerial environment and decreases the chances of carbon dioxide becoming the limiting factor in the food-making process. A proper balance of oxygen and carbon dioxide in the soil enrironment is maintained by careful watering and the proper soil structure. To obtain a healthy plant root system, there must be both large and small pore spaces in the soil, for adequate pore space serves as a reservoir in an insufficient supply of air for good root growth. If insufficient air should persist, root cell respiration will cease and the root system will decay away. In order to avoid problems of poor soil aeration, use soil conditioners such as coarse sand, coarse perlite, vermiculite, and coarse peat moss to improve soil structure. Exercise care in watering to avoid a waterlogged soil condition, which could result in poor aeration. Allow soils to dry out partially before applying the next supply of water.

Suggested Teaching-Learning Activities

1. Several experiments for investigating the environmental factors affecting plant growth are found in Using the School Greenhouse. The experiment or demonstration approach to teaching this competency is recommended.

2. Emphasize the need for understanding the environmental factors affecting plant growth by comparing the factors in plant growth with the factors in painting an automobile. (See introduction portion of the subject matter content.)

3. Involve the students in practices to control plant environment. Such activities could include the following:

   a. Applying shading compound to the greenhouse

   b. Installing heat cable in propagating beds

   c. Installing a mist system

   d. Building a lath or plastic screen shade house

   e. Keeping records of the temperature and relative humidity in the greenhouse at various times during the day and over a period of time.

   f. Watering down the aisles and areas under the benches of the greenhouse or watering a portion of the school landscape

   g. Watering various plants and crops under teacher-supervision

   h. Painting interior structures in the greenhouse white

   i. Shading a chrysanthemum crop with black cloth

   If students are asked to do many of the above-listed tasks, they will probably question the reasons for the jobs. This should create a desirable teaching opportunity.

4. Assign each student a particular plant or crop to investigate, to determine the optimum environmental conditions for growth. The Ball Red Book is a good source of information for this assignment. Students can share the results with their classmates.

5. Exhibit and use a "Gro-Lux" light.

6. Compare two relatively long-stemmed plants, one grown in the greenhouse and the other on a window sill.

7. Demonstrate the effect of different light periods on the flowering of the chrysanthemum.

8. Suggested time to develop this competency

Classroom instruction	6 hours
Laboratory activity	10 hours
Occupational experience	20 hours
Total time	36 hours

Suggested Instructional Materials and References

Instructional materials

1. Black cloth
2. Gro-Lux light
3. Greenhouse glass-shading compound
4. Day-night clock
5. Heat cable
6. Necessary materials for a misting system ($\frac{1}{2}$ inch pipe, unions, elbows and tees for $\frac{1}{2}$ inch pipe, pipe joint compound, pipe wrenches and pipe dies, nozzles, and one internal timer)

References

1. Horticultural Science, pp. 98-125, 159-199.
2. The Ball Red Book.
3. Using the School Greenhouse.

VI. To transplant seedlings, pot plants and plant annuals, perennials, shrubs, and trees in the landscape successfully

Teacher Preparation

Subject Matter Content

Moving plants from one container to another or from one location to another is common because of the necessity of propagating many plants in a relatively small space from seeds or cuttings. It is not practical and economical to start the plants in this manner, if they are not promptly transplanted. Plant growth may be slowed by any of the following:

1. Poor physical condition of the soil
2. Hardening of the seedling or cutting at the time of benching
3. An excess or a deficiency of nutrients available to the plant in the soil
4. Disease problems
5. Insect problems
6. Lack of water
7. Low temperatures

Plants should be started under the most favorable environmental conditions and gradually subjected to harsher environmental conditions in terms of plant survival requirements. This involves shifting and moving plants from the favorable conditions of the propagating house to the location where the plants are to be used. This operation involves a process called hardening, which refers to the checking of growth, resulting in an accumulation of carbohydrates. This accumulation of carbohydrates better enables the plant to withstand the more severe environmental conditions of the open field. Hardening may be accomplished by withholding water, lowering the temperature, and gradually shifting the plants from one environment to a harsher environment.

In terms of space utilization in the greenhouse, it is often impractical to place seedlings to be transplanted in large pots during the initial stages of establishment. Instead, the seedlings are transplanted into smaller pots, such as $2\frac{1}{2}$" or 3" pots, and then repotted as the plant roots approach a root-bound condition and thus require more growing space.

Tools and materials which may be used in transplanting operations are as follows:

1. Growing containers
    a. Flats
    b. Clay pots (standard type, azalea type, and bulb pans)
    c. Plastic pots
    d. Peat pots (jiffy pots)

e. Composition pots

f. Styrofoam pots

g. Herculite pots

h. Paks

i. Plastic trays

j. Veneer bands and trays

2. Row maker

3. Spotting board

4. Dibble

5. Water breaker or flat sprinkler

6. Soil drench

7. Starter solution

Transplanting, which may be harmful to plants, is certainly not beneficial. The extent to which the transplanting operation checks plant growth depends on such factors as:

1. Kind of plant being transplanted

2. Amount of injury to the root system

3. Age and size of the seedling

4. Environmental conditions following transplanting

5. Extent of previous handling

The following procedure is suggested for transplanting seedlings:

1. Prepare the media into which the plants are to be transplanted. Use good soil management practices, such as soil sterilization, soil mixtures appropriate for the plants (See Ball Red Book), and irrigation. Fill the containers to be planted to within one-half inch from the top and level off the soil surface.

2. Transplant as soon as the seedlings show their first true leaves.

3. Handle the seedlings with care, holding them lightly by their leaves, not by their stems.

4. Do not transplant weak, damaged, or malformed seedlings.

5. Dibble holes in the soil of the containers to accomodate the plants. The entire container may be dibbled at one time if an appropriate dibble board is used. (See Plant Propagation, Figures 7 and 8.)

6. Lift the seedlings from the container in which they are growing so as to cause minimum damage to the root system.

7. Handling the seedlings by the leaves, place the roots in the hole, and press the soil firmly around the root system with the thumbs and index fingers to eliminate air pockets. Be careful that the roots are neither too shallow nor too deep in the soil, and that the soil is firmed around the roots rather than just pinched around the stem. The tops of the seedling should form a level line as one looks down the flat or container from the end of the container.

Figure 15

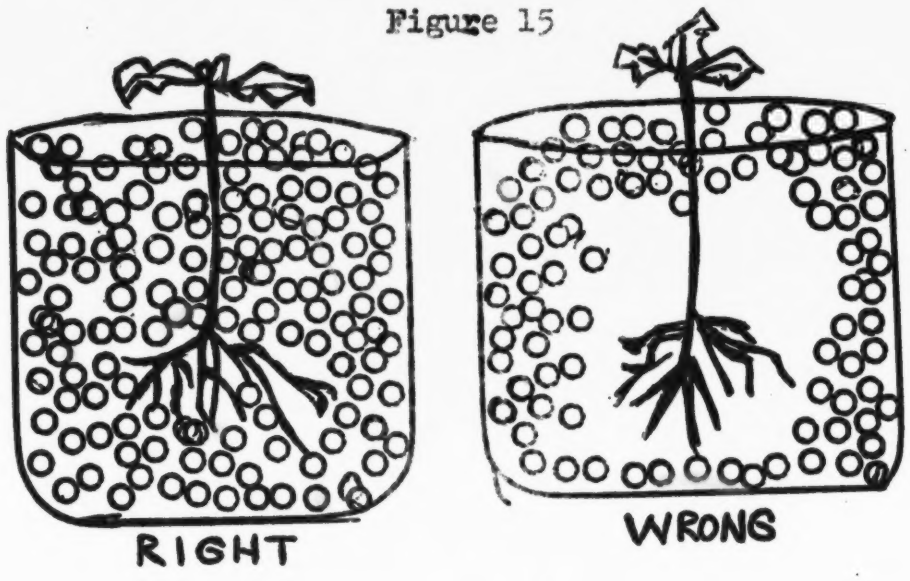


Figure 16

8. Thoroughly water the flats or containers, taking care that the seedlings are not greatly disturbed by the force of the water. Watering will help to promote good root-to-soil contact.

9. The transplanted seedlings should be shaded, held at a cool temperature, and kept from drying out for a few days until they can become re-established.

This procedure should be followed for potting plants:

If the seedlings are taken from the propagating bed to a small pot, the procedures outlined above are appropriate, but if the plants are shifted from one pot to another, the procedure is different. First, place a quantity of soil in the larger pot. Next, carefully dislodge the plant to be repotted by placing one hand on top of the pot with the plant stem between the index and second finger, invert the pot, and strike the top edge of the pot on a solid surface. Catch the plant and root ball as it falls free of the pot. Place the plant and root ball in the new container, holding the plant so that the soil surface of the ball is approximately one inch below the rim of the pot. Fill in around the plant with soil, and water thoroughly.

Figure 17

For additional reference on potting techniques, see Basic Gardening Illustrated, pp. 36-37.

For planting flower beds, follow the procedures outlined in Basic Gardening Illustrated, pp. 29-30.

Procedures for planting balled and burlapped and container-grown trees and shrubs are found in the following:

1. Basic Gardening Illustrated, pp. 31-32.

2. Tree Maintenance, Chapter 3.

3. Grounds Maintenance Handbook, pp. 86-94.

Suggested Teaching-Learning Activities

1. Prepare an exhibit of various containers used for growing plants. Discuss each type of container, mentioning its characteristics and uses. The students should be able to identify all types of growing containers as used by industry.

2. Demonstrate proper transplanting techniques and then require each student to transplant several market paks and flats containing different types of annuals and vegetable transplants. The containers should be appropriately labeled to indicate the name of the transplanter. The teacher should make frequent inspections of student work offering individual instruction, constructive criticism, and encouragement as required. The teacher should insure that each student is proficient in transplanting seedlings.

3. Require each student to repot foliage plants, geraniums, coleus, and other plants commonly shifted to larger pots as a matter of growing practice.

4. Require each student to prepare to plant an annual or perennial bed, plant several shrubs, and plant at least one tree.

5. Teacher or teacher-coached student demonstrations followed by student participation in the planting and transplanting activities required in items 2-4 above offer a desirable section for presenting the subject matter content of this competency.

6. Make some deliberate planting or transplanting errors in a series of displays. Ask the students to visit each display, noting whether the work is acceptable or unacceptable. Call on the students to explain the reasoning behind their decisions in a general class discussion.

7. Require each student to prepare and use a starter solution on transplanted crops. Compare a pak of transplanted seedlings receiving starter solution with a pak receiving no solution.

8. Suggested time to develop this competency:

Classroom teaching	4	hours
Laboratory experience	10	hours
Total time	14	hours

VII. To understand and use the necessary cultural practices for high-quality plants

Teacher Preparation

Subject Matter Content

Plants, like animals, require continuous care.

Taking Care of Animals Involves	Taking Care of Plants Involves
Feeding	Fertilizing
Watering	Watering
Providing shelter	Mulching
Sanitation	Training
Grooming	Pest Control
Medical care	Cultivation

Fertilizing as a Cultural Practice in Plant Growing

See Competency VI of the course module "Using Soil and Other Plant Growing Media Effectively." Use the subject matter content of this competency to teach the students why fertilizers are essential to plant growth.

Basically, fertilizers are used to:

1. Increase growth, yields, or production
2. Improve plant appearance
3. Improve plant quality
4. Increase plant resistance to disease
5. Help reduce winter and dry weather injury

Students should receive instruction in the following areas:

1. Learning the appropriate fertilizer analysis or formula to use in fertilizing:
   a. Annuals (bedding plants)
   b. Lawns
   c. Narrow-leaf evergreen shrubs
   d. Broadleaf evergreens
   e. Deciduous shrubs
   f. Trees
2. Rates of application
3. Methods of application to each type of plant
4. Timeliness of fertilizing
5. Handling spilled fertilizer materials
6. Safety in applying the various fertilizer materials

In presenting the above-listed material, the recommendations given by the state agricultural station should be used.

Watering Plants as a Cultural Practice in Growing Plants

Watering plants is both a cultural practice of vital importance to successful plant production and an art which can be developed through experience. When soil is watered, enough water should be applied to moisten the entire volume of soil. Good drainage must be provided to permit excess moisture to drain out of the soil. Water should be applied early enough in the day to allow the foliage of the plants to dry before the approach of darkness when the evaporative process is greatly reduced. Water should be used sparingly on plants during cloudy days. Too much water is harmful to plants because

1. Excessive water in the soil pore space tends to reduce soil aeration. Insofar as good root growth requires a good supply of air in the soil, excessive water results in poor root systems.
2. Excessive water (coupled with high temperatures) may lead to plant disease problems, especially those caused by fungi.

3. Excessive water results in rapid, soft, succulent growth, which leads to leggy plants of poor quality (especially in the case of seedling production).

Symptoms of an overwatered plant are as follows:

1. Stunted growth
2. Yellowing and dropping of the lower leaves (in the case of some plants)
3. Greatly reduced root system
4. Small leaves
5. Tall, spindly plants of poor quality (in the case of seedlings)

For additional material on watering plants, see Basic Gardening Illustrated, Chapter 4.

Students should receive instruction in the following:

1. The importance of watering as a cultural practice--Stress that watering is more than directing the stream from a hose onto the plants and the soil in which they grow. Stress through demonstrations that considerable damage can be done by improper watering practices.
2. Using different types of watering equipment systems and their components.
   a. Hose
   b. Oscillating sprinklers
   c. Water breakers
   d. Mist systems
   e. Valves
   f. Timers
   g. Mist nozzles
   h. Automatic watering systems for bench crops and pot crops
3. Correctly watering plants grown in containers

Mulching as a Cultural Practice for Growing Plants

For subject matter content concerning mulching, see Competency V of the course module "Using Soil and Other Plant Growing Media Effectively."

Pest Control as a Cultural Practice for Growing Plants

For subject matter content concerning pest control, see the course module, "Recognizing and Controlling Plant Pests."

Training as a Cultural Practice for Growing Plants

For subject matter content, see the following:

1. Basic Gardening Illustrated, pp. 60-68, and the Pruning Handbook.
2. Pruning Handbook, Brooklyn Botanic Garden Publication.
3. The Pruning Manual.

Students should receive instruction in the following:

1. The reasons for pruning and training
2. Tools used for pruning
   a. Hand pruning shears
   b. Lopping shears
   c. Hedge shears
   d. Saws
   e. Pole pruner
3. Basic techniques of pruning
   a. Uses of the various tools
   b. Making proper cuts
   c. Safety procedures
4. Pruning different types of plants
   a. Narrowleaf evergreens
   b. Broadleaf evergreens

c. Deciduous shrubs

d. Hedge

e. Trees

f. Roses

5. Use and disposal of plant trimmings

6. Espaliering

Cultivation as a Cultural Practice for Growing Plants

The primary purpose of cultivation is to reduce weed competition to growing plants.

Cultivation is defined as the loosening or breaking up of soil.

Cultivation increases soil aeration and conserves soil moisture by the formation of a soil or dust mulch; but in accomplishing these two purposes, valuable roots may be pruned off, and soil may be so loosened as to be subsequently carried away by erosive agents, such as water and wind. Insofar as this is true, the primary benefit of selective herbicides is that they tend to reduce the need for cultivation to some degree. The student should receive instruction in the following:

1. Reasons for cultivating

2. Precautions to be observed in cultivating

3. Tools used in cultivating

4. How to use cultivating equipment

Suggested Teaching-Learning Activities

1. Develop the concept that plants, like animals, require continuous care. Point out that those things which are done to care for plants are called cultural practices. In a question-and-answer session, develop with the students a list of approved plant cultural practices.

2. Demonstrate in the land laboratory the correct procedures for fertilizing flower beds, ornamental shrubs, lawns, and trees. If possible, have a representative of a tree care firm present a demonstration on tree feeding, using the various types of soil injection equipment.

3. Demonstrate how to water plants grown in containers by subsurface irrigation as well as with a water hose and appropriate water breakers. Use both correct and incorrect procedures to illustrate the necessity for using proper watering techniques.

4. Demonstrate the adjustment and use of oscillating-type lawn sprinklers.

5. Demonstrate the use of electric hedge clippers in trimming a hedge.

6. Demonstrate how to prune the following:

   a. Rose bush

   b. Flowering shrub

   c. Narrowleaf evergreen shrub

   d. Broadleaf evergreen

   e. Dwarf fruit tree

   f. Hedge

If possible, take a field trip to an old orchard to gain some pruning experience.

7. Plant a Pyracantha coccinea lalandi or other suitable woody plant at the base of a building wall and proceed to espalier the plant. An alternative would be to espalier a container-grown plant on a trellis.

8. Set up an area for controlled experiments to demonstrate the use of:

   a. Black plastic mulch

   b. Herbicides as recommended by the state experiment station for use in the nursery.

   c. Mechanical cultivation procedures

9. Demonstrate the preparation and application of pesticides using both dusters and sprayers. Stress safety in the use of these materials.

10. Show the film, "Grow Your Own," 16 minutes, black and white, U.S.D.A.

11. Suggested time to develop this competency:

Classroom instruction	18	hours
Laboratory activity	30	hours
Occupational experience	50	hours
Total time	98	hours

Suggestions for Evaluating Educational Outcomes of the Module

As a result of instruction in this course module, the student should have developed the following understandings, skills, or abilities:

1. Appreciation of the value and importance of well-grown horticultural plants
2. Evaluation of plants according to quality
3. Modifying and controlling the plant environment
4. Successfully planting, transplanting, potting, and repotting plants
5. Effectively assisting in using the various cultural practices for promoting good plant growth, including fertilizing, watering, pruning, mulching, controlling pests, and cultivating

In order to determine the ability, proficiency, and effectiveness of students in carrying out the above competencies, the teacher should administer a practical examination, such as the following:

Station 1

A series of plants of different quality. Some of the plants should be short, stocky, and well-grown. Others should be plants grown under poor light, in poor soil, under high moisture conditions, or other harmful conditions. Determine whether the students can select high-quality plants from the group.

Station 2

A series of fertilizers of different analysis and pictures of lawns, deciduous shrubs, broadleaf evergreens, narrowleaf evergreens, trees, lawns, and flower beds. Determine whether the students can match the fertilizer analysis with the plants for which the fertilizers are recommended.

Station 3

A series of examples of pruning cuts. Determine whether the students can distinguish good cuts and techniques from poor cuts and techniques.

Station 4

A series of mulching materials. Determine whether the students can identify the materials.

Observe the students as they transplant seedlings to determine their proficiency. Use the following check list. The correct answer is in parenthesis following each question.

1. Can the seedling be easily lifted from the soil when slight upward pressure is applied to a leaf? (No)

2. Do the tops of the seedlings form a level plane as one looks across the flat or pak? (Yes)

3. Does the student handle the plant by the stem or by the leaves? (By the leaves)

4. Does the student firm the soil around the roots or merely pinch the soil around the stem? (Firmed around the roots)

5. Does the student water the flat or pak evenly and uniformly by using a fine mist or sub-irrigation, or is the full force of the water directed against the seedlings? (Watered evenly and uniformly by using a fine mist or sub-irrigation)

6. Does the student place the newly-transplanted flat or pak in an area of reduced light intensity or leave the young seedlings in the direct sunlight? (Reduced light intensity)

Ask each student to plant a bare root shrub, a balled and burlapped plant, and a container-grown shrub. This may be in a practice area of the land laboratory, or it may be an actual planting in the school landscape. If planting for practice, the local nursery might cooperate in making the required plants available on a loan basis if the plants are not available in the department.

In making the evaluation of planting proficiency developed by the student, consider such questions as the following:

1. Was the top soil and subsoil separated when digging the hole?

2. Was the hole adequate in size?

3. Was a good soil mix used in the bottom of the hole?

4. Was the plant placed straight up and down in the hole, or was it leaning? (In some areas it is desirable to lean a newly-planted woody plant slightly in the direction of the prevailing wind. This should be taken into consideration.

5. Was the best side of the plant facing in the right direction?

6. Was the truck of the plant used as a handle?

Ask each student to pot or "can" several rooted woody ornamentals. Observe carefully to determine his proficiency.

Ask each student to shift geranium plants (or other appropriate plants) from $2\frac{1}{2}$-inch pots to 4-inch pots. Observe carefully to determine his proficiency.

Sources of Suggested Instructional Materials and References

Instructional materials

1. Bell Telephone Company. "Our Mr. Sun," color film, 58 minutes.

2. U.S. Department of Agriculture. "Grown Your Own," B/W film, 16 minutes.

3. "Miracles from Agriculture," color film, $13\frac{1}{2}$ minutes.

References

1. Ball. The Ball Red Book, 11th ed. West Chicago: The George J. Ball Company. Price: $2.00.

2. Brooklyn Botanic Garden. Pruning Handbook, Pub. No. 28. Baltimore: Brooklyn Botanic Garden. Price: $1.00.

3. Christopher, E. P. Introductory Horticulture. New York: McGraw-Hill Book Company, Inc., 1958.

4. Christopher, E. P. The Pruning Handbook. New York: The McMillan Company, 1961. Price: $6.95.

5. Conover, H. S. Grounds Maintenance Handbook, 2nd ed. New York: McGraw-Hill Publishing Company, Inc.

6. Drawbaugh, Charles C. Using the School Greenhouse. University Park: The Pennsylvania State University, 1963.

7. Hartmann, Hudson T., and Kenter, Dale E. Plant Propagation: Principles and Practices. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961.

8. Janick, Jules. Horticultural Science, San Francisco: W. J. Freeman Company, 1963. Price: $8.50.

9. Moon, Truman J., Mann, Paul B., and Otto, James H. Modern Biology, New York: Henry Holt and Company, 1956. Price: $5.50.

10. Morholt, Evelyn, Brandwein, Paul F., and Joseph, Alexander. Teaching High School Science: A Sourcebook for the Biological Sciences, New York: Harcourt, Brace and Company, 1958.

11. Nelson, Kennard S. Flower and Plant Production in the Greenhouse, Danville: Interstate Printers and Publishers, 1965. (This book will be available October 1, 1965.)

12. Pirone, P. P. Tree Maintenance, New York: Oxford University Press, 1959. Price: $11.

13. Sunset Series. Basic Gardening Illustrated, Menlo Park, New Jersey: Lane Publishing Company, 1963. Price: $1.95.

14. Sunset Series. Pruning Handbook, Menlo Park, New Jersey: Lane Publishing Company. Price: $1.95.

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INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
_____

6. How many students:
a) Were enrolled in class (total) _____
b) Participated in studying this module _____
c) Participated in a related occupational work experience program while you taught this module _____

7.

Actual time spent teaching module:		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE . . . . . NOT APPROPRIATE
8. The suggested time allotments given with this module were:	
9. The suggestions for introducing this module were:	
10. The suggested competencies to be developed were:	
11. For your particular class situation, the level of subject matter content was:	
12. The Suggested Teaching-Learning Activities were:	
13. The Suggested Instructional Materials and References were:	
14. The Suggested Occupational Experiences were:	

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)